Ph.D. Synopsis entitled

Geological and Hydrogeomorphological assessment of the Upper Purna River basin, western India using remote sensing and GIS techniques

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Introduction

The use of remote sensing and GIS techniques has revolutionized the field of geology and hydrogeomorphology. These advanced technologies have enabled researchers to map and analyze landscape changes caused by natural and anthropogenic phenomena, leading to a better understanding of the causes and consequences of these changes. With this information, effective strategies for managing and mitigating the impact of these natural processes can be created, ultimately leading to a safer and more sustainable environment.

The geological study of a river basin plays a crucial role in shaping the hydrological patterns and overall topography of the region. Through the employment of advanced techniques, such as remote sensing and GIS, we can gain a more comprehensive understanding of the geological features that define the basin and how they might impact the functioning of the river system. Armed with this knowledge, we can devise effective management plans that prioritize the preservation of the environment while ensuring its long-term sustainability. Water is crucial for sustaining life and is a vital natural resource. Humans rely on water for domestic, agricultural, and industrial purposes. However, overexploitation of groundwater has become a major issue in the last two decades. Groundwater is the only source of fresh water in many areas, and protecting it is a high-priority management goal. The pace of development has resulted in haphazard construction, leading to the loss of environmental assets like gardens and water bodies. Unlike other regions, the study area has no perennial river, and many lakes were constructed across seasonal streams in the past. Hydrogeomorphology is an essential field of study that explores the relationship between the physical characteristics of a river basin and the hydrological processes that occur within it. By examining the geological features of the region, we can gain a better understanding of how water flows through the system and how it interacts with the surrounding environment.

The integration of remote sensing and Geographic Information System (GIS) technologies has brought about a significant transformation in the realm of geology and hydrogeomorphology. This innovative approach has enabled scientists and researchers to gain a deeper understanding of various natural phenomena and develop effective strategies for managing and mitigating their impact. The utilization of remote sensing and GIS techniques

has facilitated the creation of detailed maps, spatial analyses, and accurate models that have greatly enhanced our ability to comprehend and address various geological and hydrological issues. This has led to the development of better decision-making frameworks and more efficient management strategies, ultimately contributing to the sustainable management of natural resources. Conducting an impact assessment of a river basin is a crucial step in understanding the effects of human activities on the environment. It involves analyzing the ecological, social, and economic impacts of any development or changes in the river basin. The assessment helps in identifying potential risks and benefits, and developing strategies to mitigate the negative effects while maximizing the positive ones. By conducting a thorough impact assessment, we can ensure that our actions are sustainable and do not harm the delicate balance of nature in the river basin.

When evaluating the impact of geological and hydrogeomorphological transformations, it is crucial to take into account the utilization of remote sensing and GIS methods. These cutting-edge technologies offer a wealth of information on the reasons and outcomes of landscape alterations resulting from natural phenomena. By meticulously analyzing this data, we can devise effective strategies that will enable us to manage and reduce the impact of these natural processes. This approach will ultimately lead to the creation of a safer and more sustainable environment for all.

Location of the study area

The Purna River originates from the Ajanta hill ranges in Maharashtra's Aurangabad district. It is a major left bank tributary of the Godavari River and flows southeast until it discharges into the Godavari River near Katneshwar village in Purna tehsil. The study area lies between latitude 19°38′ N to 20°33′ N and longitude 75°10′ E to 76°50′ E. It has been included in the Survey of India (SoI) toposheets 46P/3, P/4, P/6, P/7, P/8, P/10, P/11, P/12, P/14, P/15, P/16, 47M/1, M/5, 47D/9, D/13, 55D/2, D/3, D/4, D/7, D/8, D/12, 56A/1, A/5, A/6, A/9, A/10, A/13, and A/14. It has a total area of 7401 km^2 and falls in the Aurangabad, Jalna, Buldhana, Washim, Parbhani and Hingoli districts in the state of Maharashtra. The Upper Purna basin includes about 200 villages and 07 towns and has a total population of about 5,00,000 (COI 2011). The study area has large tracts of fertile land for agriculture. The area has a semi-arid subtropical climate with hot summers, except for the monsoon period. Generally, the weather is dry. The location of the study area is shown in Toposheet indexing in Fig. 1.

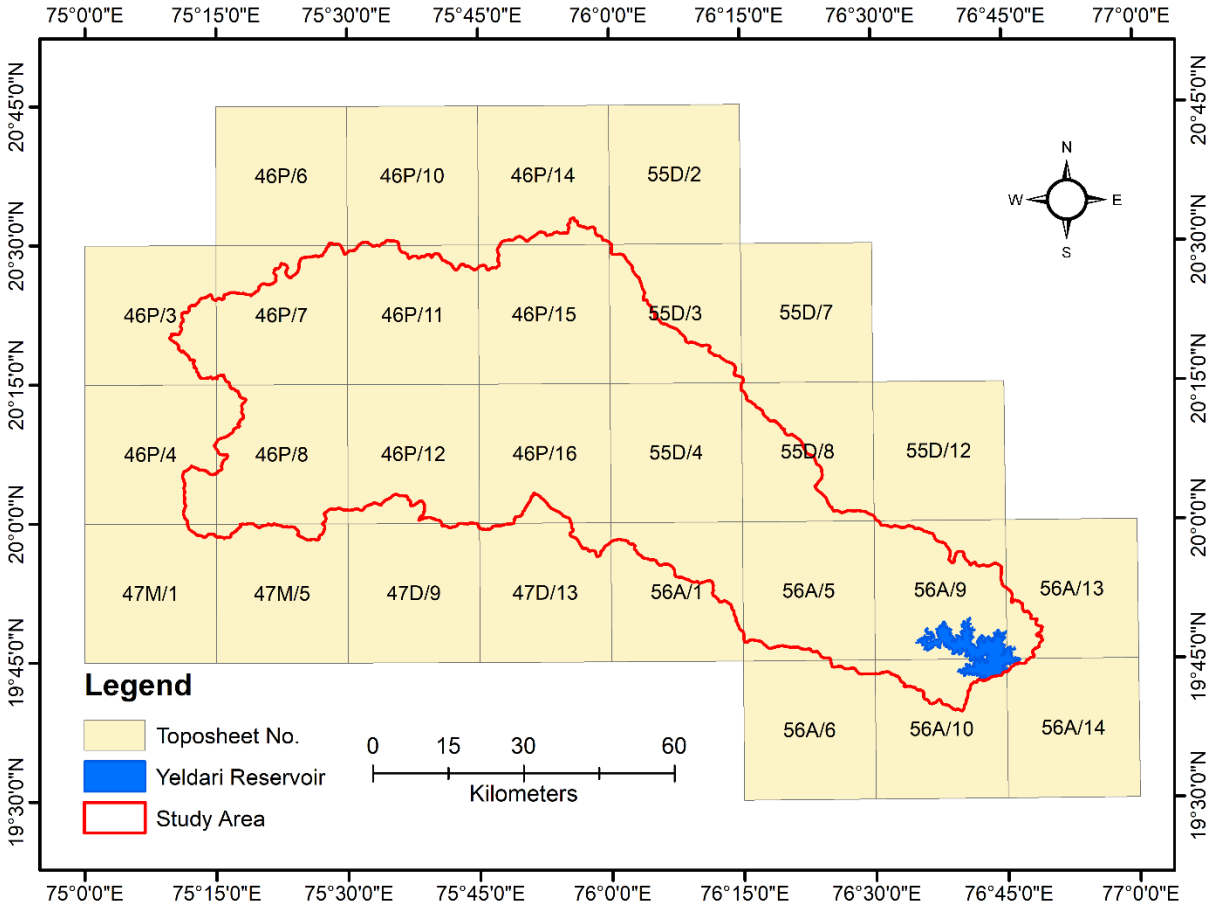

Fig. 1. Toposheet indexing

Objectives

1) To record and illustrate the geology, and hydrogeomorphology of the Upper Purna river basin.
2) To establish relationships between morphometric parameters and groundwater potential zones, basin morphometry is studied based on geomorphological analysis.
3) To study the characteristics of the terrain, including its shape, area, altitude, slope, and profiles, and explain the overall evolution of the basin.
4) To map and monitor land use and land cover changes in the study area.
5) To study soil erosion, soil types, and their impact on water quality.
6) To study various environmental impacts such as groundwater pollution, agricultural pollution, overexploitation, flood, and drought.

National Status

Remote sensing and geographic information system (GIS) have proved to be important tools for preparing thematic maps from satellite images and is also used as a multi-criteria decision analysis tool (Vittala et al., 2005; Madrucci et al., 2008; Mondal et al., 2008; Javed & Wani, 2009; Jha et al., 2010; Dar et al., 2010; Ghute et al., 2023). Application of remote sensing and GIS in geology and geomorphology for quick hydrogeological evaluation has been proven to be efficient (Pareta & Pareta, 2011; Suganthi et al., 2013; Anbazhagan & Jothibasu, 2014; Ndatuwong & Yadav, 2014). Interpretation of various features has also been done by visual method, which is time-consuming and difficult in areas where accessibility is not possible for humans. To overcome these constraints, integrating remote sensing and GIS methods gives more accuracy and reduces the risk of manual error (Pinder, 2002; Prasad et al., 2008; Dar et al., 2011; Jasmin & Mallikarjuna, 2011). Another advantage is that both discrete and continuous data from primary and secondary sources can be combined and interpreted by this method (Burrough, 1986). Rai et al. (2005), Karunanidhi et al. (2013), Rashid et al. (2012), and Srinivasan et al. (2013) complemented remote sensing methods with geoelectrical studies to identify the groundwater prospective zones. Researchers have also used statistical methods (Ozdemir, 2011; Machiwal et al., 2011; Manap et al., 2012, 2013; Pinto et al., 2015) and numerical modeling (Chenini & Mammou, 2010; Gaur et al., 2011; Ahmad et al., 2011) along with GIS for groundwater potential mapping. Ideally, GIS is a rapid and cost-effective problem-solving platform for identifying groundwater potential zones. If this method is complemented with necessary ground checks, it will be an effective technique in hydrogeomorphological studies.

International Status

The scientific understanding of geomorphic form-process relationships that are essential to the behavior and condition of a river has been slow to transfer into river management policy and practice. Although most management and restoration activities focus on the river reach, which is the scale at which river managers primarily interact with, assess, and monitor rivers, the hydrogeomorphological condition of a river reach is influenced by processes operating at larger spatial and longer temporal scales (Brierley & Fryirs, 2005; Grabowski & Gurnell, 2014).

Early geomorphological studies emphasized the importance of physical factors (e.g. valley and river channel gradient, water and sediment discharge, bed, and bank sediment size, etc.) in driving channel adjustment and change, and developed conceptual and empirical models of

river channel morphodynamics, but more recently, the additional importance of vegetation to the geomorphic functioning of river systems has been recognized (Corenblit et al., 2007; Gurnell, 2014).

Materials and Methods

The following methodology will be adopted for the Geological and Hydrogeomorphological impact assessment of the study area.

1. Collection of literature relevant to the present study. A critical review of the available geologic and hydrogeomorphological information to understand the overall geological setup of the area in a regional context.
2. The base map of the Upper Purna river basin will be prepared using survey of India topographic maps on an average scale of 1: 50,000 by using ArcGIS and its various tools.
3. Geological features and geo-fluviometric features will be traced using satellite data which will also help in the identification of sites.
4. The field mapping will focus on identifying various landforms and morpho-fluvial features, particularly terraces and hill slopes. A key priority is determining how the geomorphic setting affects the hydrogeology of the river basin.
5. The slope map will be created using Aster DEM data with 30m resolution in the ArcGIS Spatial Analyst module. The drainage density, lineament density, and lithological maps were generated through line density analysis and on-screen digitization methods in ArcGIS. Thematic layers such as land use, lithology, and lineament were demarcated using geo-coded Landsat ETM+ satellite data on a scale of 1:50,000 with UTM projection, spheroid, and datum WGS 84.
6. Detailed geomorphic and drainage analysis will be carried out using parameters known to morphometric, geomorphic setup and fluvial architecture.
7. Implanting methods for morphometric analysis of given basin such as drainage density, stream ratio, mean stream length and others.
8. Thematic layers were converted to a 30m raster format and overlapped using geospatial analysis in ArcGIS to determine groundwater potential zones.
9. Additionally, we create and compare various thematic maps, including geological, land cover, geomorphological, drainage, and groundwater potential maps.
10. The data collected in the field and lab will be analyzed to create a model of the geology and hydrogeomorphology of the Uppar Purna River basin.

Significance of the study

Interdisciplinary research is still needed in the areas of geology and hydrogeomorphology to appropriately implement UPR basin assessment and monitoring procedures within the scope of watershed health. Watersheds should be considered as basic landscape units for understanding natural resources and environmental issues. This review has focused on issues surrounding the geologic and geomorphologic application to watershed problem-solving. Despite applied geomorphology long but largely unrepresented history within the watershed health discipline, escalating environmental awareness and better technical expertise have brought increased opportunities to contribute to integrated watershed management. Linking the geologic and geomorphologic characteristics with the health concept of the watershed can provide a scientific basis and more accurate and simpler way to apply effective and fruitful strategies to identify particular areas within the watershed that should receive a higher priority for management. In addition, it needs to learn more about related terminologies to geology and geomorphology concepts like hydro-geomorphologic, eco-geomorphologic, and other similar ones and obtain more comprehensive information. It does not forget to give more attention to know more about the nexus of geological and geomorphological sectors with other like ecology, hydrology, climate etc. This knowledge is crucial for developing effective management strategies that prioritize the preservation of the natural ecosystem while promoting sustainable development. By using advanced techniques like remote sensing and GIS, we can gather valuable data that allows us to create accurate and detailed hydrogeomorphic maps of the region, which can be used to inform decision-making and guide future research projets and development in the study area as well as basin management.

Proposed work plan

The Literature relevant to the present study was used as a guide. Toposheets and geological maps were collected, while Google Earth images were utilized to provide accessible images. Preliminary surveys were conducted to identify accessible sites in the study region. Geoprocessing was carried out using a Geographic Information System (GIS) to provide hydromorphological information of the region. A systematic methodology was adopted in the present research to fulfill various objectives, which included the preparation of base maps using toposheets, thematic maps, satellite data, GIS, DEM, and TEM.

First Year:

Literature review/survey: A literature review was conducted to understand the geological and geomorphological context of the study area. The first step in the geomorphological study involved analyzing morphometric parameters quantitatively. Google Earth images were used to plan preliminary surveys and identify accessible sites in the study region.

Second Year:

Then, a detailed field investigation is planned to identify drainage types, map sediments and fluvial architecture using a GIS platform. Morphometric analysis will be conducted using Survey of India toposheets and satellite imageries.

Third Year:

After analyzing and interpreting geological and hydrogeomorphological data, the thesis will be written and submitted at the end of the year. Additionally, the research will be presented at various conferences and published in reputed journals.

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